June 13, 1933. A. L. MATTE 1,913,496

AUTOMATIC RECORDER FOR TRANSMISSION EFFICIENCY

Filed Dec. 18, 1930 2 Sheets-Sheet 1

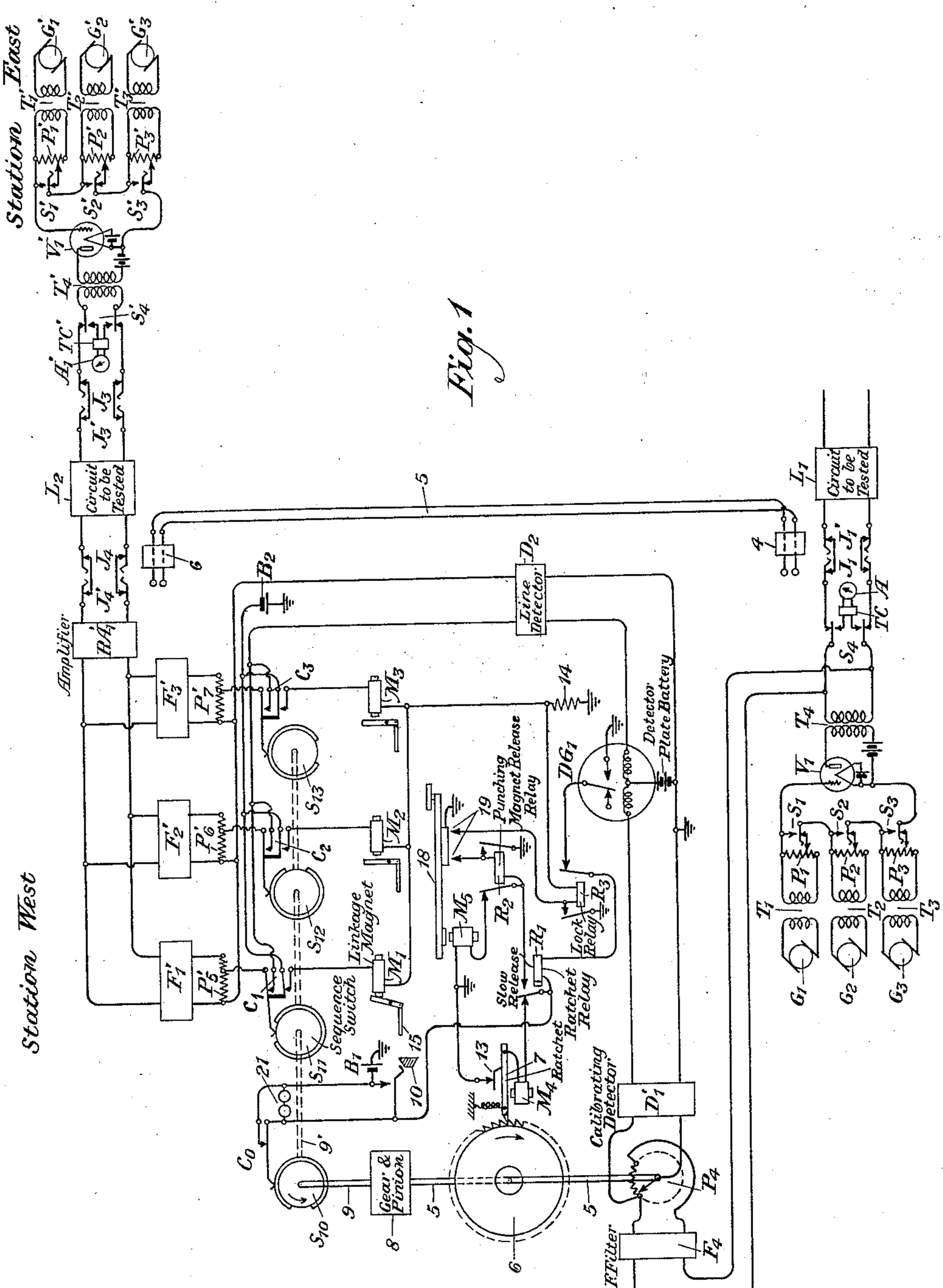

Fig. 1

INVENTOR
A. L. Matte
BY
ATTORNEY

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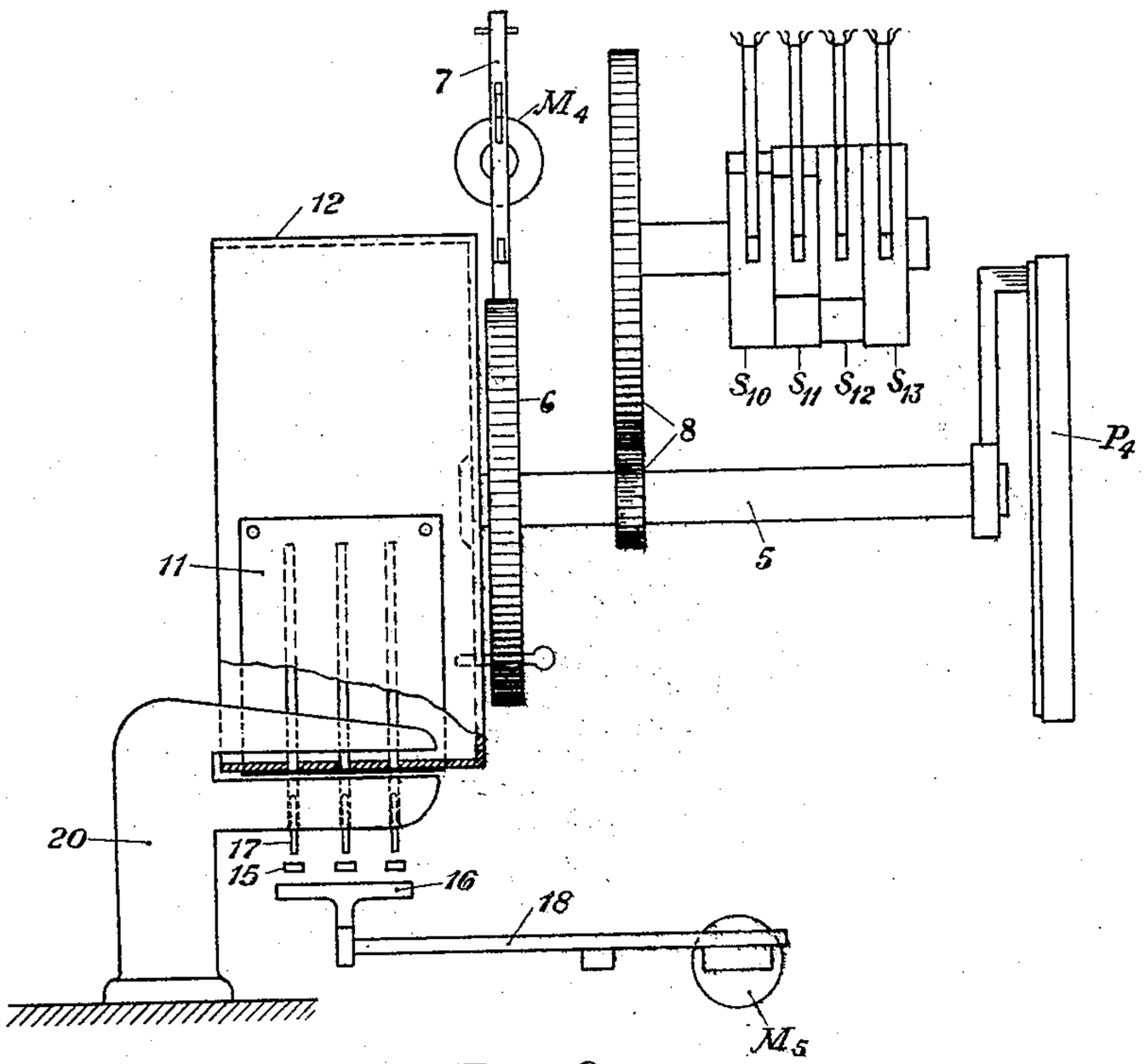

Fig. 2

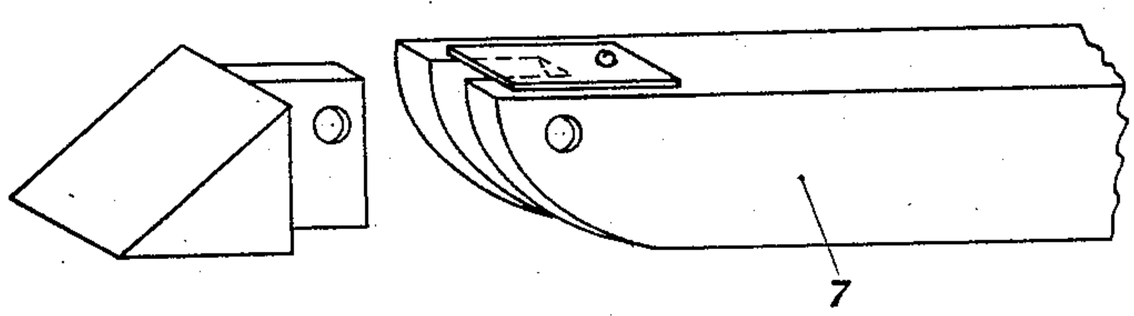

Fig. 3

INVENTOR
A. L. Matte

BY

ATTORNEY

Patented June 13, 1933 1,913,496

UNITED STATES PATENT OFFICE

ANDREW L. MATTE, OF SUMMIT, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK

AUTOMATIC RECORDER FOR TRANSMISSION EFFICIENCY

Application filed December 18, 1930. Serial No. 503,342.

This invention relates to a system for automatically determining and recording the transmission efficiency of a circuit, and particularly to a system in which such transmission efficiency is measured at each of a plurality of frequencies, which frequencies are transmitted simultaneously over the said circuit.

In the copending application of A. L. Matte, Serial No. 503,341, filed Dec. 18, 1930, there is described a system for indicating and also for recording manually the transmission efficiency of a circuit at each of a plurality of frequencies during the simultaneous transmission of all of the measuring frequencies. As pointed out in detail in that application, the transmission efficiency of a circuit made up solely of resistances and free from external interference, when measured at a single frequency, would be the same regardless of whether that frequency were the only one present in the system or was one of a plurality of frequencies simultaneously present. That equality does not exist in the case of long transmission lines, particularly where relatively high energy levels are used, because overloading and modulation effects take place. Those phenomena produce parasitic currents that introduce an error in the measurement of the transmission efficiency at a single frequency.

In the said copending application there have been described several arrangements by which the error caused by those parasitic currents may be eliminated. Those arrangements produce either a visual indication or a graphic record of such efficiency by manual operation.

The present invention resides in an arrangement for automatically recording on a suitably printed chart the transmission efficiency of a circuit at each of a plurality of frequencies during the simultaneous transmission of all of such frequencies.

Other objects of the invention will be apparent from the following description, when read in connection with the attached drawings, of which Figure 1 is a circuit diagram showing schematically one form of embodiment of the invention; Fig. 2 shows certain of the mechanical features of the arrangement shown in Fig. 1; and Fig. 3 is a detail of a ratchet employed in the arrangements of the other figures.

In Fig. 1, G_1, G_2, and G_3 at the west station represent sources of current of different frequencies that are employed in determining the transmission efficiency of a circuit. While only three generators are shown, it is to be understood that the number of frequencies may be greater or less than three, and that any well known source or sources of current may be employed. The generators are connected by the transformers T_1, T_2, and T_3 with the potentiometers P_1, P_2 and P_3, respectively. The potentiometers are adapted to be connected by the switches S_1, S_2, and S_3 with the input side of the vacuum tube V_1 that acts as a voltage adder. The output of that tube is connected by the transformer T_4 with the switch S_4 which, when thrown inward, connects the output circuit with the measuring apparatus, and when thrown outward, impresses the output voltage upon the circuit L_1. The arrangement just described is similar to that shown in Fig. 1 of the copending application. Plug 4 of the cord 5 is adapted to be inserted in the jacks J_1 in order to connect the output of the generating system just described with the input of the amplifier RA_1' when the plug 6 is inserted in the jack J_4'. As pointed out in the copending application, those jacks are strapped together by the cord 5 during the process of calibrating the measuring apparatus, but that such cord is removed during the transmission of the testing currents over the circuit L_2 whose efficiency is to be measured by the apparatus at the left hand side of the figure.

A similar group of generators G_1', G_2', and G_3' shown at the east station at the right-hand side of Fig. 1, produce currents of the same frequencies as generators G_1, G_2, and G_3. The generators G_1', G_2', and G_3' are connected by the transformers T_1', T_2', and T_3' with the potentiometers P_1', P_2', and P_3'. The latter are connected by their associated switches with the vacuum tube V_1' that functions as a voltage adder. The output of that

tube is connected with the switch S_4' so that the current may be applied either to the circuit L_2 or to the thermocouple TC′ and its associated milliammeter A_1'. The current transmitted by L_2 will be impressed upon the amplifier RA_1' whose output is connected with the branch circuits each of which contains one of the filters F_1', F_2', and F_3'. Associated with the filters are the potentiometers P_5', P_6', and P_7' that may be adjusted once for all to calibrate the apparatus prior to the making of the measurements of transmission efficiency of the circuits such as L_2. The voltages across the potentiometers will be impressed upon the line detector D_2 by the operation of the sequence switches S_{11}, S_{12}, and S_{13}. The lower contact of each of the group of contacts controlled by the sequence switches controls one of the linkage magnets M_1, M_2, and M_3 whose function is to control the fingers connected with their armatures, which fingers, as shown in Fig. 2, enable the hammer 16 to force the pins through the recording paper and thus produce a record of the measurement by such perforation. The rectified current of the line detector D_2 passes through the right-hand winding of the differential galvanometer DG_1. The left-hand winding of that galvanometer is connected with the output of the calibrating detector D_1' which is connected with the potentiometer P_4. The calibrating current is derived, for purposes of illustration from the source shown at the left-hand side of the figure, one of the frequencies being selected by the filter F_4 and impressed upon the potentiometer P_4. The movable arm of P_4 is connected with the shaft 5 with which is also connected the gear 6 that is rotated by the ratchet 7. The movement of the latter is controlled by the ratchet magnet M_4. The shaft 5 is connected by the gear and pinion 8 with a shaft 9 that controls the sequence switch S_{10} and the other sequence switches previously mentioned. The shaft 5 also drives the recording drum 12, as shown in Fig. 2. The sequence switch S_{10} through its contacts C_0 controls the disconnection of the battery B_1 from certain of the relays of the system after a cycle of operations has been completed. The push button 10 is used to start the cycle of operations. The closing of its contact connects the battery B_1 with the ratchet magnet M_4 and causes the rotation of the gear 6. The ratchet relay R_1, when operated, effects the energization of the printing magnet M_5; R_2 is the printing magnet release relay whose function is to release the printing magnet upon the completion of the making of the record; and R_3 is the locking relay that serves to prevent a second operation of the recording device at the same testing frequency, until the completion of a testing cycle.

The manner in which the system is calibrated is as follows: Let it be assumed that the generators G_1, G_2, and G_3 are operating and that the potentiometers P_1, P_2, and P_3 have been adjusted so that a predetermined voltage at each frequency is impressed upon the tube V_1. The manner of making that adjustment is fully described in the said copending application. The output current of the said tube flows partly through the circuit that leads to the filter F_4. One of the frequencies will be transmitted through the filter and will be impressed across the potentiometer P_4. The transformer T_4 is always connected through the switch S_4 to a circuit having an impedance equal to that of the circuit to be measured. The current that passes F_4 will be rectified by D_1' and impressed upon the left-hand winding of the differential galvanometer DG_1, which, in this particular embodiment, is essentially a sensitive relay, the tongue of which will remain on either contact whenever the current through its two windings are equal, and will move over from one contact to the other when the currents differ by an amount which is negligibly small compared with the accuracy desired in the measurements.

The plugs 4 and 6 are then inserted in the jacks J_1 and J_4' and the switch S_4 is thrown to connect the output of the tube V_1 with the input of the amplifier RA_1'. The current of all frequencies, as amplified by RA_1', will be impressed upon the branched output circuit and the several frequencies will be selected by the filters and the voltages of the several frequencies will be impressed across the respective fixed potentiometers P_5', P_6' and P_7'. With only one of the received frequencies impressed at a time on D_2 (depending on the position of shaft 9′), and P_4 in the position corresponding to zero equivalent on the chart, each of the fixed potentiometers, P_5', P_6', etc., is adjusted till the tongue of DG_1 just leaves its left-hand contact and moves over to the grounded or right-hand contact. The desired adjustments of the shafts may be made by rotating the drum 12 by hand.

After the automatic measuring and recording apparatus has been calibrated in the manner just described, it is ready for measuring the transmission efficiency of the circuit L_2. The generators G_1', G_2', and G_3' are effectively connected with the said circuit after their potentiometers have been adjusted to apply known amounts of voltage to the adding tube V_1. The plugs 4 and 6 of the cord 5 are removed from the jacks J_1 and J_4', respectively. The latter disconnection effectively connects the circuit L_2 with the input of the amplifier RA_1' so that the currents of the various frequencies transmitted over that circuit will be amplified and impressed upon the various branches containing the networks, each selective of one of the frequencies transmitted.

It will be assumed that a chart 11 has been placed upon the drum 12 of the arrangement shown in Fig. 2, and furthermore assumed that the switch S_{10} is in such position that its contact C_0 is open. Under these conditions the whole mechanism is at a stand still. P_4 is in such a position that the input to D_1' is shorted and the galvanometer DG_1 is on its left-hand contact; the drum 12 is also so placed that the end of the chart corresponding to the minimum measureable equivalent is about to pass over the pin 17. The button 10 is pushed, thereby connecting the battery B_1 with a circuit that includes the left-hand contact of relay R_1, the magnet M_4, the ratchet 7 and its contact 13 which is grounded. The flow of current through M_4 attracts the ratchet and causes the rotation of the gear 6 in the direction indicated by the arrow. As soon as the gear rotates, the shaft to which it is attached will simultaneously cause the rotation of the switch S_{10} and also the arm of the potentiometer P_4. The rotation of S_{10} raises its arm and closes its contact, thereby continuing the connection of the battery B_1 with the ratchet magnet even though the button 10 may be released. The rotation of the arm of P_4 increases the voltage applied to the detector D_1' and likewise the current flowing through the left-hand winding of DG_1. The ratchet 7 will continue to move up and down and the gear 6 will continue to rotate till the sequence switches reach the position shown in the drawing which represents the condition for the measurement of the frequency that passes the filter F_1'. Under the condition shown the contacts C_1 of switch S_{11} will be closed. The closing of the upper contact connects the potentiometer with the line detector D_2, which in turn is connected with the right-hand winding of the galvanometer DG_1. The closing of the lower contact of C_1 permits current to flow from battery B_2 over the said contact and through the magnet M_1 and the resistance 14 to ground. The operation of M_1 causes the movement of the finger 15 so as to bring it between the hammer 16 and the lower end of the pin 17 of the recording device, all of which is clearly shown in Fig. 2. During the closing of the contact C_1 the ratchet 7 will continue to operate and the potentiometer P_4 will be moved around until a point is reached where the current in the left-hand winding overcomes that in the right-hand winding. Thereupon the armature of the galvanometer will move to its right-hand contact which is grounded. Current will thereupon flow from the battery B_1 through relay R_1 and the right-hand contact of R_3 to ground and will operate relay R_1. That disconnects the battery B_1 from the ratchet magnet M_4 and stops the rotation of the gear 6 and its associated apparatus. The operation of relay R_1 also connects battery B_1 through the right-hand contact of R_1 and the left-hand contact of R_2 with the printing magnet M_5 to ground, causing the operation of the latter. When the printing magnet operates, it attracts its armature, which rotates the shaft 18 and causes the hammer 16 to strike the finger 15, forcing the latter to strike the end of the pin 17 and thereby to cause a perforation of the paper chart 11 that is carried by the drum 12. The rotation of the shaft 18 also closes the contacts 19, thereby permitting the flow of current from B_1 through the winding of the release relay R_2 and the locking relay R_3 and resistance 14 to ground. Both of the latter relays are energized and locked up. As will be seen, relay R_3 derives its operating voltage from the drop in potential through resistance 14. The operation of relay R_2 opens the circuit of the printing magnet M_5, thereby permitting its armature to drop back. As soon as relay R_3 has operated, the opening of its right-hand contact will remove the ground from the ratchet relay R_1, which is established through DG_1. Since the locking relay R_3 operates upon the drop in potential of the current from the battery B_2 through the resistance 14, the said locking relay will remain operated as long as the sequence switch S_{11} maintains the lower contacts C_1 closed. That prevents the operation of relay R_1 and in turn the operation of the printing magnet M_5, thus rendering impossible the operation of the punching apparatus until the frequency has changed. As soon as the relay R_1 releases, R_2 will drop back into its normal unoperated position and the ratchet magnet M_4 will be energized, thus starting the rotation of the gear 6 which will continue steadily until the punching operation is about to occur for the next testing frequency.

As soon as the cam of the switch S_{11} rotates to lift its movable arm and to open C_1, the current will cease flowing through the resistance 14 and relay R_3 will be released. Likewise, the magnet M_1 will be deenergized and the finger 15 will be withdrawn, for example by a spring (not shown) from the space between the hammer and the lower end of its associated pin. The shaft 9' will continue to rotate and will cause the closing of the contacts C_2 associated with the switch S_{12}, thus impressing the second testing frequency upon the line detector D_2. The same cycle of operations will occur as described above and upon the completion thereof the third testing frequency will be connected with the system from the switch S_{13}. Obviously, any number of frequencies may be employed by the use of additional equipment similar to that described.

The gear ratio of the pinion to the gear connected with the shafts 5 and 9, respectively, is 1 to N where N is the number of test frequencies. On the other hand, the resistance of the potentiometer P_4 spans an

angle equal to that of the active part of the chart. The recesses of each cam S_{11}, S_{12}, etc., correspond to the angles covered by the chart. After all of the frequencies have been recorded, the arm of the switch S_{10} drops into its recess, thereby opening the contact C_0. That brings the apparatus to a standstill by effectively disconnecting battery B_1 from M_4, simultaneously rings a high resistance alarm 21 to call the attendant's attention to the fact that the record is complete.

The invention is not limited to the form shown in the figures, but is capable of embodiment in a variety of other forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a system for automatically recording the transmission efficiency of a circuit, the combination with a circuit over which is transmitted a testing current comprising a plurality of frequencies, of means for selecting each frequency, means to rectify and to apply each selected frequency to a differential indicating device to which is also applied a measuring current whose magnitude is controllable at will, means to automatically adjust the measuring current to have a predetermined ratio to the testing current in the said indicating device, and means to record the transmission efficiency of the circuit for the selected frequency when such ratio is effected.

2. In a system for automatically recording the transmission efficiency of a circuit, the combination with a circuit of a plurality of sources of currents of different frequencies connected with the said circuit, the magnitude of each component frequency being known, means also connected with the said circuit to select each of the said frequencies, a differential relay, a rectifier connected to one of the windings of the said relay, a sequence switch adapted to apply the currents of different frequencies successively and automatically to the said rectifier, another source of known magnitude connected to the other winding of the relay, the said connection including a potentiometer and means to automatically adjust the setting of the potentiometer until the currents in the windings of the relay differ by a predetermined amount, and means to repeat the said automatic adjustment of the potentiometer for each of the other frequencies in succession.

3. The method for automatically recording the transmission efficiency of a circuit which consists in transmitting a plurality of frequencies over a line and selecting one of the said frequencies, locally generating a plurality of frequencies and selecting one of them, rectifying each selected frequency, automatically adjusting the magnitude of the selected frequency from the local source until the effect of the rectified currents upon a responsive device causes it to change from one contact to another, and automatically recording the transmission efficiency of the said line for the selected frequency.

4. In a system for automatically recording the transmission efficiency of a circuit over which a plurality of currents of known magnitude and frequency are transmitted, the combination with a plurality of branch circuits each having a filter selective of one of the said frequencies, of a plurality of sequence switches each individual to one of the said branch circuits, a gear and ratchet having an operating magnet associated therewith adapted to rotate the said sequence switches, a plurality of rectifiers, a differential galvanometer having each winding connected with one of the said rectifiers, means controlled at will to start the energization of the operating magnet of the said ratchet whereby one of the said selecting switches will connect its branch circuit with the input of one of said rectifiers, a local source of current effectively connected to the relay, the connection including a potentiometer and a rectifier, the said potentiometer being so operated by the said gear as to vary the magnitude of the current supplied by the local source to its rectifier, the variation continuing until a predetermined difference exists in the said differential galvanometer, and means to automatically stop the rotation of the said gear when the said difference occurs.

5. In a system for automatically recording the transmission efficiency of a circuit over which a plurality of currents of known magnitude and frequency are transmitted, the combination with means to automatically select each of the said frequencies in succession of means to rectify the selected frequency, a local source of direct current, a differential device upon which both currents are impressed, means to automatically vary the magnitude of the local current until a predetermined difference exists in said indicating device, and means responsive thereupon to automatically record the transmission efficiency of the circuit at the frequency then selected.

6. In a system for automatically recording the transmission efficiency of a circuit over which a plurality of currents of known magnitude and frequency are transmitted, the combination with a drum of a chart carried thereon, means to rotate the said drum, means to set in operation the said rotating means, a plurality of pins each adapted to perforate the said chart to record the transmission efficiency of the circuit at one of the said frequencies, a plurality of sequence switches and a potentiometer, all driven by the same rotating means, a differential relay upon which are impressed the current from a local source and also the current of each of the testing frequencies in succession, means controlled

by the differential relay to stop the rotation of the said drum, and means to operate that pin corresponding to the test frequency then being applied to the said differential relay, whereby the transmission efficiency of a circuit at that frequency may be recorded, and means to repeat such recording at all test frequencies successively and automatically.

7. In a system for automatically recording the transmission efficiency of a circuit over which a plurality of currents of known magnitude and frequency are transmitted, the combination with a drum of a chart carried thereon, means to rotate the said drum, means to set in operation the said rotating means, a plurality of pins each adapted to perforate the said chart to record the transmission efficiency of the circuit at one of the said frequencies, a plurality of sequence switches and a potentiometer, all driven by the same rotating means, a differential relay upon which are impressed the current from a local source and also the current of each of the testing frequencies in succession, means controlled by the differential relay to stop the rotation of the said drum, means to operate that pin corresponding to the test frequency then being applied to the said differential relay, and means to prevent the making of more than one measurement at each test frequency during each cycle of a plurality of measurements.

8. In a system for automatically recording the transmission efficiency of a circuit, the combination with a circuit over which is transmitted a testing current comprising a plurality of frequencies, of means to separate the frequencies after transmission, a differential relay, means to selectively apply the separated frequencies singly and in successive order to one winding of the said relay, means to apply to the other winding of said relay a measuring current, means to automatically adjust the magnitude of the measuring current until it overcomes the effect upon the said relay of the testing current of the frequency then selected, means responsive to said relay to stop the adjustment of the measuring current and means to automatically record the transmission efficiency of the testing current of the frequency then selected.

In testimony whereof, I have signed my name to this specification this 17th day of December, 1930.

ANDREW L. MATTE.